



TITLE:

Theory of Limit of Inflammability (II) : Lower Limit

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RIGHT:

N ₂	0.5	0.8660	2441	2407	1.01
	1.5	0.7385	2081	2055	1.01
	2.5	0.6637	1871	1822	1.03
H ₂	1	1.200	3382	3273	1.03
	2	1.279	3605	3527	1.02
	3	1.309	2990	3532	1.05
He	0.75	1.124	3168	3010	1.05
	1.5	1.166	3282	3130	1.05
	2.5	1.176	3315	3160	1.05
A	0.75	0.744	2097	1950	1.08
	1.5	0.648	1825	1800	1.02
	2.5	0.573	1616	1700	0.95
2.82 He 18A <i>M_X</i> =14.8*	2.0	0.870	2451	2390	1.03
1.5 He 15A <i>M_X</i> =22.0**	1.5	0.801	2258	2330	0.97

$$* \quad M_X = \frac{4 \times 2.28 + 40 \times 1.18}{2.82 + 1.18} = 1.48$$

$$** \quad M_X = \frac{4 \times 1.5 + 40 \times 1.5}{1.5 + 15} = 22.0$$

2. Theory of Limit of Inflammability. (II)

Lower Limit

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According to the theory proposed by Goto (Rev. Phys. Chem. Japan, 21, 152 (1942)), the correlation between lower limit of inflammability (c_1) and molar heat of combustion (Q) can be expressed by the equation

$$\frac{1}{c_1} = \frac{k}{E} Q + k, \quad (1)$$

where k is a constant and E the heat of activation. The linear relation found between $\frac{1}{c_1}$ and Q suggests that the activation energy of combustion E is almost constant for most of combustible gases and vapors. By the method of least squares, we have $k/E = 0.090$, $k = 1.56$ and accordingly $E = 17$ (Kcal). Assuming that the heat of combustion are distributed equally among all degrees of freedom of excess molecules in a unit volume per one molecule of combustible and that the flame propagation can occur when the energy distributed to every one of oxygen molecule exceeds the activation energy E , the condition for inflammation was given by the relation

$$c_1(Q+E) + \frac{1}{2}fRT = E \quad (2)$$

where f is the degree of freedom of an oxygen molecule, R the gas constant and T the absolute temperature. Since Eq. (2) can be written in the form

$$\frac{1}{c_1} = \frac{Q}{E - \frac{1}{2}fRT} + \frac{E}{E - \frac{1}{2}fRT}, \quad (3)$$

Eq. (2) or (3) is another expression of Eq. (1). From Eq. (2) or (3), the activation energy E and the temperature coefficient of c_1 was estimated as shown in the next table.

Table 1. Temperature coefficients of lower limit and heat of activation.

Combustible	Kcal/mole	Temp. Coeff. ($\times 10^5$)		E (Kcal/mole) from Eq. (3)
		$\Delta C_1/\Delta T$ obs.	$fR/2Q$ calc.	
Hydrogen	58	$(\frac{0.034}{350})$: 9.5	12	7.7(8.8%; 100°C)
Carbon monoxide	68	$(\frac{0.030}{200})$: 15	12	12.8(15%; 100°C)
Ammonium	76	$(\frac{0.045}{400})$: 11	9	15.9(17.5%; 100°C)
Methane	196	$(\frac{0.022}{500})$: 4.4	4	13.1(5.5%; 100°C)
Pentane	775	$(\frac{0.0031}{233})$: 1.1	0.9	13.8(1.53%; 17°C)
Benzene	751	$(\frac{0.0024}{150})$: 1.6	0.9	12.8(1.37%; 100°C)
Toluene	892	$(\frac{0.0023}{100})$: 2.3	0.8	13.8(1.26%; 100°C)
Ethylene	311	$(\frac{0.0095}{383})$: 2.5	2.3	12.7(3.45%; 17°C)
Acetylene	302	$(\frac{0.0071}{283})$: 2.3	2.3	10.6(2.90%; 17°C)
Methanol	150	$(\frac{0.016}{200})$: 8.0	4.7	13.4(7.5%; 50°C)
Propylalcohol	438	$(\frac{0.007}{150})$: 4.7	1.6	13.4(2.45%; 100°C)
Acetone	395	$(\frac{0.0008}{100})$: 8.0	1.8	13.8(3.0%; 25°C)

Mean value of E : 1208.

3. Theory of Limit of Inflammability. (III)

Upper Limit

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Similarly to the case of lower limit, the energy of combustion (ϵ) equally distributed to every degree of freedom of molecules in an unit volume per